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HOLIDAY LAKE, HURON COUNTY, OHIO

Pacific Northwest Environmental
Research Laboratory

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16. ABSTRACT

Annual total phosphorus and total nitrogen loadings to the lake were estimated and subdivided according to either point or non-point source origin. An assessment of the lake's trophic condition and limiting nutrient is also provided. All data collected by the U.S.E.P.A. National Eutrophication Survey during the one year study of the lake and its tributaries are included in the report.

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NATIONAL EUTROPHICATION SURVEY

WORKING PAPER SERIES

REPORT
ON
HOLIDAY LAKE
HURON COUNTY
OHIO
EPA REGION V
WORKING PAPER No. 402

PACIFIC NORTHWEST ENVIRONMENTAL RESEARCH LABORATORY

An Associate Laboratory of the

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REPORT
ON
HOLIDAY LAKE
HURON COUNTY
OHIO
EPA REGION V
WORKING PAPER No. 402

WITH THE COOPERATION OF THE
OHIO ENVIRONMENTAL PROTECTION AGENCY
AND THE
OHIO NATIONAL GUARD
JUNE, 1975

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FOREWORD

The National Eutrophication Survey was initiated in 1972 in response to an Administration commitment to investigate the nation-wide threat of accelerated eutrophication to fresh water lakes and reservoirs.

OBJECTIVES

The Survey was designed to develop, in conjunction with state environmental agencies, information on nutrient sources, concentrations, and impact on selected freshwater lakes as a basis for formulating comprehensive and coordinated national, regional, and state management practices relating to point-source discharge reduction and non-point source pollution abatement in lake watersheds.

ANALYTIC APPROACH

The mathematical and statistical procedures selected for the Survey's eutrophication analysis are based on related concepts that:

a. A generalized representation or model relating sources, concentrations, and impacts can be constructed.

b. By applying measurements of relevant parameters associated with lake degradation, the generalized model can be transformed into an operational representation of a lake, its drainage basin, and related nutrients.

c. With such a transformation, an assessment of the potential for eutrophication control can be made.

LAKE ANALYSIS

In this report, the first stage of evaluation of lake and watershed data collected from the study lake and its drainage basin is documented. The report is formatted to provide state environmental agencies with specific information for basin planning [§303(e)], water quality criteria/standards review [§303(c)], clean lakes [§314(a,b)], and water quality monitoring [§106 and §305(b)] activities mandated by the Federal Water Pollution Control Act Amendments of 1972.

Beyond the single lake analysis, broader based correlations between nutrient concentrations (and loading) and trophic condition are being made to advance the rationale and data base for refinement of nutrient water quality criteria for the Nation's fresh water lakes. Likewise, multivariate evaluations for the relationships between land use, nutrient export, and trophic condition, by lake class or use, are being developed to assist in the formulation of planning guidelines and policies by EPA and to augment plans implementation by the states.

ACKNOWLEDGMENT

The staff of the National Eutrophication Survey (Office of Research & Development, U. S. Environmental Protection Agency) expresses sincere appreciation to the Ohio Environmental Protection Agency for professional involvement, to the Ohio National Guard for conducting the tributary sampling phase of the Survey, and to those Ohio wastewater treatment plant operators who provided effluent samples and flow data.

Ned Williams, Director, and Tom Birch, Ken Carr, Larry Dietrick, Ron Havlice, Larry Korecko, Rod Mehlhop, Terry Wheeler, and John Yougер, Ohio Environmental Protection Agency, provided invaluable lake documentation and counsel during the Survey, reviewed the preliminary reports, and provided critiques most useful in the preparation of this Working Paper series.

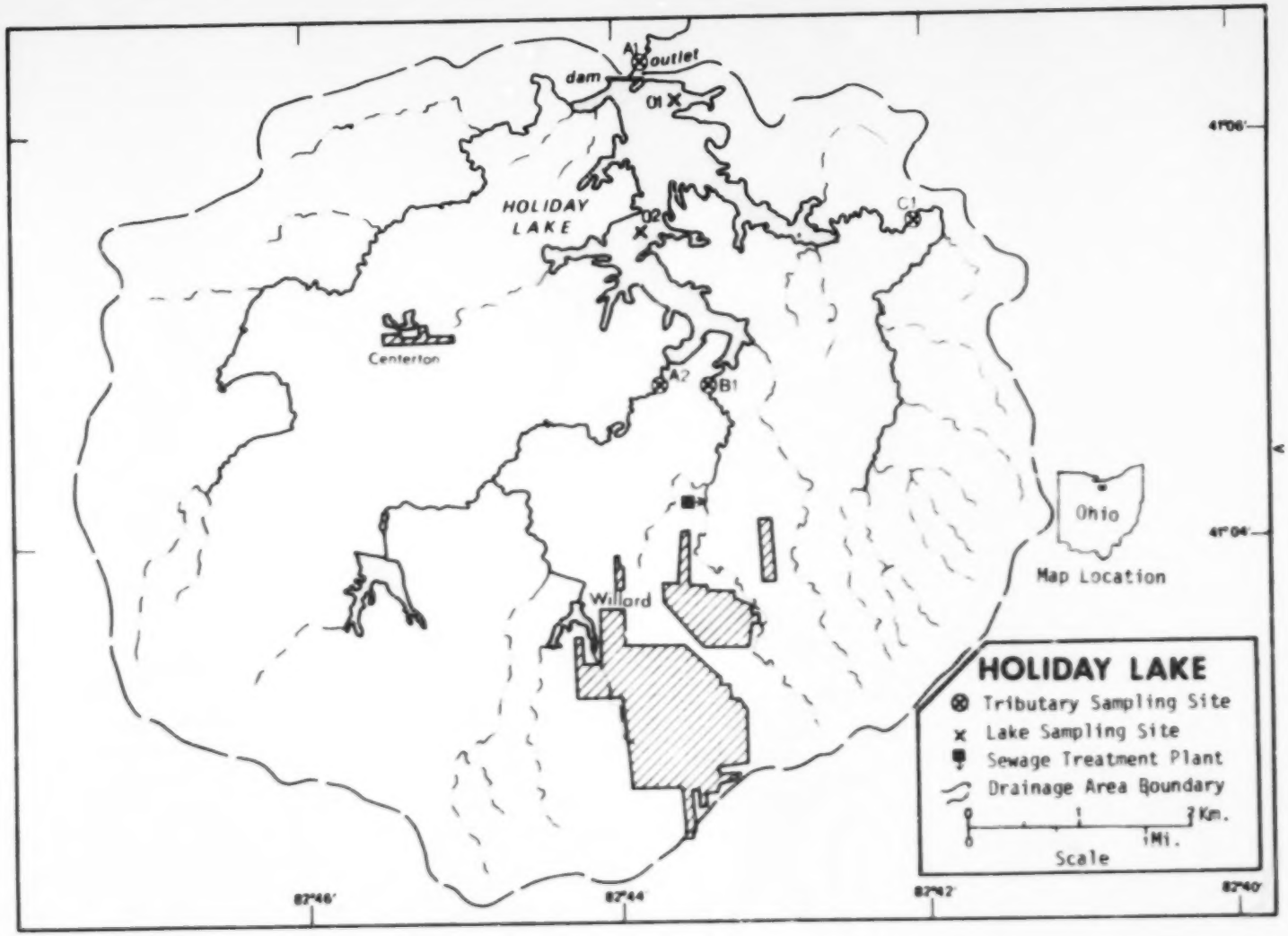
Major General Dana L. Stewart, then the Adjutant General of Ohio, and Project Officer Lt. Colonel Robert C. Timmons, who directed the volunteer efforts of the Ohio National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

NATIONAL EUTROPHICATION SURVEY

STUDY LAKES

STATE OF OHIO

LAKE NAME	COUNTY
Atwood	Carroll, Tuscarawas
Beach City	Stark, Tuscarawas
Berlin	Mahoning, Portage, Stark
Buckeye	Fairfield, Licking, Perry
Charles Mill	Ashland, Richland
Deer Creek	Fayette, Pickaway
Delaware	Delaware
Dillon	Muskingum
Grand Lake of St. Marys	Auglaize, Mercer
Grant	Brown
Holiday	Huron
Hoover	Delaware, Franklin
Indian	Logan
Loramie	Auglaize, Shelby
Mosquito Creek	Trumbull
O'Shaughnessy	Delaware
Pymatuning	Ashtabula, OH; Crawford, PA
Pleasant Hill	Ashland, Richland
Rocky Fork	Highland
Shawnee	Greene
Tappan	Harrison


A1
outlet
dam
O1
HOLIDAY
LAKE
O2
C1
Centerton
A2
B1
Willard
Ohio
Map Location
41°06'
41°04'
82°46'
82°44'
82°42'
82°40'
HOLIDAY LAKE
Tributary Sampling Site
Lake Sampling Site
Sewage Treatment Plant
Drainage Area Boundary
0
1
2 Km.
0
1 Mi.
Scale

HOLIDAY LAKE

STORET NO. 3930

I. CONCLUSIONS

A. Trophic Condition:

Survey data show that Holiday Lake is eutrophic. It ranked fifteenth in overall trophic quality when compared to the other 19 Ohio lakes sampled in 1973 using a combination of six lake parameters*. Thirteen of the lakes had less median total phosphorus, 16 had less median dissolved phosphorus, nine had less median inorganic nitrogen, 14 had less mean chlorophyll a, and three had greater mean Secchi disc transparency. Depletion of dissolved oxygen with depth occurred at station 2 in July.

It is reported that algae and aquatic weeds are summer problems in Holiday Lake (Ketelle and Uttormark, 1971).

B. Rate-Limiting Nutrient:

The algal assay results indicate phosphorus limitation at the time the sample was taken (07/27/73). The lake data also indicate phosphorus limitation in July; however, nitrogen limitation is indicated in October.

C. Nutrient Controllability:

1. Point sources--The Willard wastewater treatment facility is estimated to have contributed 81.7% of the total phosphorus load reaching the lake during the sampling year. Septic tanks are estimated to have contributed 0.5%.

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* See Appendix A.

The present loading of 8.41 $g/m^2/yr$ is nearly 12 times that proposed by Vollenweider (Vollenweider and Dillon, 1974) as a eutrophic loading (see page 11). While even complete removal of the phosphorus loads from the Willard wastewater treatment plant and the septic tanks would only reduce the loading to 1.5 $g/m^2/yr$ (about twice the eutrophic loading), it is likely that a high degree of phosphorus removal at the Willard plant would result in an improvement in the water quality of Holiday Lake.

2. Non-point sources--Phosphorus from non-point sources amounted to 17.8% of the total load reaching the lake, but none of the tributaries had high export rates (see page 11).

The Unnamed Streams A-2 and C-1 contributed 8.2% and 3.1%, respectively. The ungaged drainage area was estimated to have contributed 4.1%.

II. LAKE AND DRAINAGE BASIN CHARACTERISTICS†

A. Lake Morphometry††:

1. Surface area: 0.19 kilometers^2.
2. Mean depth: 3.9 meters.
3. Maximum depth: >4.9 meters.
4. Volume: 3.549×10^6 m^3.
5. Mean hydraulic retention time: 103 days.

B. Tributary and Outlet:
(See Appendix C for flow data)

1. Tributaries -

Name	Drainage area (km^2)*	Mean flow (m^3/sec)*
Unnamed Stream (A-2)	14.7	0.1
Unnamed Stream (B-1)	4.5	<0.1
Unnamed Stream (C-1)	7.3	0.1
Minor tributaries & immediate drainage -	8.3	0.1
Totals	34.8	0.4

2. Outlet -

Unnamed Stream (A-1)	35.7**	0.4

C. Precipitation***:

1. Year of sampling: 99.4 centimeters.
2. Mean annual: 89.4 centimeters.

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† Table of metric equivalents--Appendix B.
†† Youger, 1975.
* For limits of accuracy, see Working Paper No. 175, "...Survey Methods, 1973-1976".
** Includes area of lake.
*** See Working Paper No. 175.

III. LAKE WATER QUALITY SUMMARY

Holiday Lake was sampled two times during the open-water season of 1973 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from two stations on the lake and from two or more depths at each station (see map, page v). During each visit, a single depth-integrated (near bottom to surface) sample was composited from the stations for phytoplankton identification and enumeration; and during the July visit, a single 18.9-liter depth-integrated sample was composited for algal assays. Also each time, a depth-integrated sample was collected from each of the stations for chlorophyll *a* analysis. The maximum depths sampled were 2.7 meters at station 1 and 4.9 meters at station 2.

The lake sampling results are presented in full in Appendix D and are summarized in the following table.

A. SUMMARY OF PHYSICAL AND CHEMICAL CHARACTERISTICS FOR HOLIDAY LAKE
STORET CODE 3930

PARAMETER	1ST SAMPLING (7/27/73) 2 SITES RANGE	MEAN	MEDIAN	2ND SAMPLING (10/ 6/73) 2 SITES RANGE	MEAN	MEDIAN	3RD SAMPLING (10/ 8/73) 0 SITES RANGE	MEAN	MEDIAN
TEMP (C)	21.7 - 26.7	25.5	26.2	19.6 - 20.0	19.9	20.0	******	**********	
DISS OXY (MG/L)	0.0 - 9.4	5.4	7.2	7.2 - 8.2	7.5	7.3	******	**********	
CNDCTVY (MCROMO)	546. - 579.	560.	560.	506. - 532.	522.	530.	******	**********	
PH (STAND UNITS)	7.2 - 8.8	8.1	8.3	7.9 - 8.4	8.1	8.0	******	**********	
TOT ALK (MG/L)	116. - 192.	133.	121.	125. - 131.	129.	130.	******	**********	
TOT P (MG/L)	0.068 - 0.408	0.132	0.086	0.142 - 0.256	0.196	0.214	******	**********	
ORTHO P (MG/L)	0.010 - 0.249	0.053	0.019	0.033 - 0.085	0.063	0.076	******	**********	
NO2+NO3 (MG/L)	0.080 - 0.160	0.117	0.120	0.150 - 0.180	0.160	0.150	******	**********	
AMMONIA (MG/L)	0.100 - 3.800	0.824	0.300	0.390 - 0.660	0.550	0.640	******	**********	
KJEL N (MG/L)	1.480 - 5.300	2.229	1.700	2.300 - 3.000	2.720	2.900	******	**********	
INORG N (MG/L)	0.180 - 3.920	0.941	0.460	0.560 - 0.810	0.710	0.790	******	**********	
TOTAL N (MG/L)	1.480 - 5.420	2.346	1.860	2.470 - 3.150	2.880	3.050	******	**********	
CHLRPYL A (UG/L)	14.9 - 43.4	29.1	29.1	56.0 - 107.1	81.5	81.5	******	**********	
SECCHI (METERS)	0.9 - 0.9	0.9	0.9	0.8 - 0.8	0.8	0.8	******	**********	

B. Biological characteristics:

1. Phytoplankton* -

Sampling Date	Dominant Genera	Algal Units per ml
10/06/73	1. *Coelosphaerium sp.*	827
	2. *Microcystis sp.*	229
	3. *Melosira sp.*	92
	4. *Cryptomonas sp.*	46
	5. *Trachelomonas sp.*	23
	Other genera	139
	Total	1,356

2. Chlorophyll *a* -

Sampling Date	Station Number	Chlorophyll *a* (µg/l)
07/27/73	01	43.4
	02	14.9
10/06/73	01	107.1
	02	56.0

C. Limiting Nutrient Study:

1. Autoclaved, filtered, and nutrient spiked -

Spike (mg/l)	Ortho P Conc. (mg/l)	Inorganic N Conc. (mg/l)	Maximum yield (mg/l-dry wt.)
Control	0.056	1.178	21.0
0.050 P	0.106	1.178	24.0
1.0 N	0.056	2.178	20.0

2. Discussion -

The control yield of the assay alga, *Selenastrum capricornutum*, indicates that the potential primary productivity of Holiday Lake was very high at the time the assay sample was collected.

There was some increase in yield with an increase in

* The July phytoplankton sample was lost in shipment.

orthophosphorus, but the growth response was not significantly different than the control when only nitrogen was added (i.e., phosphorus limitation is indicated). Note that the combined phosphorus and nitrogen spike was inadvertently omitted.

The assay alga may have been inhibited by other factors since none of the yields reached the maximum potential. This suggests a possible toxic substance and/or limitation by some other factor.

The lake data indicate phosphorus limitation in July (the mean inorganic nitrogen/orthophosphorus ratio was 16/1, and phosphorus limitation would be expected). However, nitrogen limitation is indicated in October when the mean N/P ratio was 11/1.

IV. NUTRIENT LOADINGS
(See Appendix E for data)

For the determination of nutrient loadings, the Ohio National Guard collected monthly near-surface grab samples from each of the tributary sites indicated on the map (page v), except for the high runoff months of February and March when two samples were collected. Sampling was begun in May, 1973, and was completed in April, 1974.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year were provided by the Ohio District Office of the U.S. Geological Survey for the tributary sites nearest the lake.

In this report, nutrient loads for sampled tributaries, except the Unnamed Stream (B-1), were determined by using a modification of a U.S. Geological Survey computer program for calculating stream loadings*. However, the nutrient loads estimated for the Willard wastewater treatment plant exceeded the loads measured in the Unnamed Stream at station B-1, and the background nutrient loadings for this stream and the unsampled "minor tributaries and immediate drainage" ("ZZ" of U.S.G.S.) were estimated using the means of the nutrient loads, in $kg/km^2/year$, at stations A-2 and C-1 and multiplying the means by the B-1 and ZZ areas in km^2.

The community of Willard did not participate in the Survey, and nutrient loads were estimated at 1.134 kg P and 3.401 N/capita/year. It is assumed that all of the loads reached the lake during the sampling year.

* See Working Paper No. 175.

A. Waste Sources:

1. Known municipal* -

Name	Pop. Served**	Treatment	Mean Flow (m^3/d)***	Receiving Water
Willard	5,510	trickling filter	2,085.5	Unnamed Creek (B-1)

2. Known industrial - None

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

Source	kg P/yr	% of total
a. Tributaries (non-point load) -		
Unnamed Stream (A-2)	625	8.2
Unnamed Stream (B-1)	170	2.2
Unnamed Stream (C-1)	240	3.1
b. Minor tributaries & immediate drainage (non-point load) -	315	4.1
c. Known municipal STP's -		
Willard	6,250	81.7
d. Septic tanks† -	35	0.5
e. Known industrial - None	-	-
f. Direct precipitation†† -	15	0.2
Total	7,650	100.0

2. Outputs -

Lake outlet - Unnamed Stream (A-1) 1,495

3. Net annual P accumulation - 6,155 kg.

---

* Anonymous, 1971.
** 1970 Census.
*** Estimate based on 0.3785 m^3/capita/day.
† Estimate based on 130 shoreline dwellings; see Working Paper No. 175.
†† See Working Paper No. 175.

C. Annual Total Nitrogen Loading - Average Year:

1. Inputs -

Source	kg N/ yr	% of total
a. Tributaries (non-point load) -		
Unnamed Stream (A-2)	14,790	23.6
Unnamed Stream (B-1)	5,595	8.9
Unnamed Stream (C-1)	10,800	17.3
b. Minor tributaries & immediate drainage (non-point load) -	10,315	16.5
c. Known municipal STP's -		
Willard	18,740	29.9
d. Septic tanks* -	1,385	2.2
e. Known industrial - None	-	-
f. Direct precipitation** -	980	1.6
Total	62,605	100.0

2. Outputs -

Lake outlet - Unnamed Stream (A-1)	28,635

3. Net annual N accumulation - 33,970 kg.

* Estimate based on 130 shoreline dwellings; see Working Paper No. 175.
** See Working Paper No. 175.

D. Mean Annual Non-point Nutrient Export by Subdrainage Area:

Tributary	kg P/km²/yr	kg N/km²/yr
Unnamed Stream (A-2)	43	1,006
Unnamed Stream (C-1)	33	1,479

E. Yearly Loadings:

In the following table, the existing phosphorus loadings are compared to those proposed by Vollenweider (Vollenweider and Dillon, 1974). Essentially, his "dangerous" loading is one at which the receiving water would become eutrophic or remain eutrophic; his "permissible" loading is that which would result in the receiving water remaining oligotrophic or becoming oligotrophic if morphometry permitted. A mesotrophic loading would be considered one between "dangerous" and "permissible".

Note that Vollenweider's model may not be applicable to water bodies with short hydraulic retention times.

	Total Phosphorus		Total Nitrogen	
	Total	Accumulated	Total	Accumulated
grams/m²/yr	8.41	6.76	68.8	37.3

Vollenweider phosphorus loadings (g/m²/yr) based on mean depth and mean hydraulic retention time of Holiday Lakes:

"Dangerous" (eutrophic loading)	0.72
"Permissible" (oligotrophic loading)	0.36

V. LITERATURE REVIEWED

Anonymous, 1971. Inventory of municipal waste facilities. EPA Publ. OWP-1, vol. 5, Wash., DC.

Ketelle, Martha J., and Paul D. Uttormark, 1971. Problem lakes in the United States. EPA Water Poll. Contr. Res. Ser., Proj. #16010 EHR, Washington, DC.

Vollenweider, R. A., and P. J. Dillon, 1974. The application of the phosphorus loading concept to eutrophication research. Natl. Res. Council of Canada Publ. No. 13690, Canada Centre for Inland Waters, Burlington, Ontario.

Youger, John, 1975. Personal communication (lake morphometry). OH Env. Prot. Agency, Columbus.

VI. APPENDICES

APPENDIX A

LAKE RANKINGS

LAKES RANKED BY INDEX NOS.

RANK	LAKE CODE	LAKE NAME	INDEX NO
1	3926	ATWOOD RESERVOIR	491
2	3921	MOSQUITO CREEK RESERVOIR	483
3	3924	PLEASANT HILL LAKE	431
4	3929	BERLIN RESERVOIR	429
5	3914	HOOVER RESERVOIR	392
6	3934	TAPPAN LAKE	381
7	3927	LAKE SAINT MARYS	297
8	3932	ROCKY FORK LAKE	292
9	3906	DEER CREEK RESERVOIR	290
10	3901	BEACH CITY RESERVOIR	277
11	3915	INDIAN LAKE	266
12	3907	DELAWARE RESERVOIR	263
13	3912	GRANT LAKE	261
14	3933	SHAWNEE LAKE	249
15	3930	HOLIDAY LAKE	220
16	3905	CHARLES MILL RESERVOIR	216
17	3902	BUCKEYE LAKE	207
18	3908	DILLION RESERVOIR	206
19	3917	LORAMIE LAKE	178
20	3931	O'SHAUGNESSY RESERVOIR	173

PERCENT OF LAKES WITH HIGHER VALUES (NUMBER OF LAKES WITH HIGHER VALUES)

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG N	500-MEAN SEC	MEAN CHLORA	15-MIN DO	MEDIAN DISS ORTHO P	INDEX NO
3901	BEACH CITY RESERVOIR	37 (7)	21 (4)	11 (2)	84 (16)	82 (15)	42 (8)	277
3902	BUCKEYE LAKE	11 (2)	76 (14)	5 (1)	0 (0)	89 (17)	26 (5)	207
3905	CHARLES MILL RESERVOIR	26 (5)	63 (12)	37 (7)	21 (4)	11 (0)	58 (11)	216
3906	DEER CREEK RESERVOIR	53 (10)	5 (1)	63 (12)	95 (18)	63 (12)	11 (2)	290
3907	DELAWARE RESERVOIR	58 (11)	16 (3)	32 (6)	89 (17)	47 (9)	21 (4)	263
3908	DILLION RESERVOIR	16 (3)	32 (6)	42 (8)	58 (11)	53 (10)	5 (1)	206
3912	GRANT LAKE	47 (9)	58 (11)	16 (3)	32 (6)	74 (14)	34 (6)	261
3914	HOOVER RESERVOIR	87 (16)	26 (5)	89 (17)	79 (15)	32 (6)	79 (15)	392
3915	INDIAN LAKE	42 (8)	76 (14)	21 (4)	16 (3)	58 (11)	53 (10)	266
3917	LOHAMIE LAKE	5 (1)	37 (7)	0 (0)	5 (1)	97 (18)	34 (6)	178
3921	MOSQUITO CREEK RESERVOIR	74 (14)	100 (19)	82 (15)	53 (10)	82 (15)	92 (17)	483
3924	PLEASANT HILL LAKE	95 (18)	68 (13)	100 (19)	63 (12)	39 (7)	66 (12)	431
3927	LAKE SAINT MARYS	21 (4)	95 (18)	26 (5)	11 (2)	97 (18)	47 (9)	297
3928	ATWOOD RESERVOIR	100 (19)	89 (17)	95 (18)	68 (13)	39 (7)	100 (19)	491
3929	BERLIN RESERVOIR	79 (15)	42 (8)	74 (14)	74 (14)	68 (13)	92 (17)	429
3930	HOLIDAY LAKE	32 (6)	53 (10)	82 (15)	26 (5)	11 (0)	15 (3)	220
3931	O'SHAUGNESSY RESERVOIR	0 (0)	0 (0)	47 (9)	100 (19)	26 (5)	0 (0)	173
3932	ROCKY FORK LAKE	68 (13)	47 (9)	58 (11)	42 (8)	11 (0)	66 (12)	292
3933	SHAWNEE LAKE	63 (12)	11 (2)	53 (10)	37 (7)	11 (0)	74 (14)	249
3934	TAPPAN LAKE	87 (16)	84 (16)	68 (13)	47 (9)	11 (0)	84 (16)	381

LAKE DATA TO BE USED IN RANKINGS

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG N	500-MEAN SEC	MEAN CHLORA	15-MIN [illegible]	MEDIAN DISS ORTHO P
3901	BEACH CITY RESERVOIR	0.122	1.490	489.000	10.867	11.000	0.015
3902	BUCKEYE LAKE	0.179	0.380	490.000	186.567	4.600	0.020
3905	CHARLES MILL RESERVOIR	0.127	0.465	482.555	57.144	15.000	0.011
3906	DEER CREEK RESERVOIR	0.09[illegible]	[illegible].480	470.125	9.857	13.400	0.038
3907	DELAWARE RESERVOIR	0.084	[illegible].340	[illegible].111	10.[illegible]	14.500	0.024
3908	DILLION RESERVOIR	0.163	1.590	481.250	27.400	14.300	0.037
3912	GRANT LAKE	0.113	0.570	486.333	40.533	12.200	0.019
3914	HOOVER RESERVOIR	0.040	1.440	482.750	13.017	14.800	0.008
3915	INDIAN LAKE	0.120	0.380	485.222	78.455	14.200	0.012
3917	LOHAMIE LAKE	0.185	1.380	494.000	104.100	8.200	0.019
3921	MOSQUITO CREEK RESERVOIR	0.054	0.150	485.333	36.267	11.800	0.008
3924	PLEASANT HILL LAKE	0.036	0.455	456.833	22.850	14.700	0.010
3927	LAKE SAINT MARYS	0.148	0.200	484.167	79.150	8.200	0.014
3928	ATWOOD RESERVOIR	0.031	0.205	492.000	16.442	14.700	0.005
3929	BERLIN RESERVOIR	0.042	0.400	485.435	15.496	13.600	0.006
3930	HOLIDAY LAKE	0.125	0.575	485.333	55.350	15.000	0.034
3931	O'SHAUGNESSY RESERVOIR	0.204	3.070	474.333	5.522	14.900	0.159
3932	ROCKY FORK LAKE	0.067	0.790	473.000	38.022	15.000	0.010
3933	SHAWNEE LAKE	0.069	2.380	474.333	39.567	15.000	0.009
3934	TAPPAN LAKE	0.043	0.280	486.111	37.711	15.000	0.007

APPENDIX B

CONVERSIONS FACTORS

CONVERSION FACTORS

Hectares x 2.471 = acres

Kilometers x 0.6214 = miles

Meters x 3.281 = feet

Cubic meters x 8.107×10^{-4} = acre/feet

Square kilometers x 0.3861 = square miles

Cubic meters/sec x 35.315 = cubic feet/sec

Centimeters x 0.3937 = inches

Kilograms x 2.205 = pounds

Kilograms/square kilometer x 5.711 = lbs/square mile

APPENDIX C

TRIBUTARY FLOW DATA

TRIBUTARY FLOW INFORMATION FOR OHIO 1/27/75

LAKE CODE 3930 HOLIDAY LAKE

TOTAL DRAINAGE AREA OF LAKE(SQ KM) 35.7

TRIBUTARY	SUB-DRAINAGE AREA(SQ KM)	NORMALIZED FLOWS(CMS) JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
3930A1	35.7	0.51	0.62	0.91	0.74	0.42	0.23	0.13	0.07	0.05	0.06	0.13	0.28	0.35
3930A2	14.7	0.21	0.26	0.37	0.31	0.18	0.09	0.06	0.03	0.02	0.02	0.05	0.12	0.14
3930B1	4.5	0.06	0.08	0.12	0.10	0.05	0.03	0.02	0.01	0.01	0.01	0.02	0.04	0.04
3930C1	7.3	0.10	0.13	0.19	0.15	0.09	0.05	0.03	0.01	0.01	0.01	0.03	0.06	0.07
3930Z2	9.2	0.13	0.16	0.24	0.19	0.11	0.06	0.04	0.02	0.01	0.01	0.03	0.07	0.09

SUMMARY

TOTAL DRAINAGE AREA OF LAKE = 35.7
SUM OF SUB-DRAINAGE AREAS = 35.7
TOTAL FLOW IN = 4.18
TOTAL FLOW OUT = 4.18

MEAN MONTHLY FLOWS AND DAILY FLOWS(CMS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
3930A1	5	73	0.68	5	0.26				
	6	73	0.74	2	0.20				
	7	73	0.34	2	0.23				
	8	73	0.10	6	0.05				
	9	73	0.05	16	0.03				
	10	73	0.18	7	0.05				
	11	73	0.27	11	0.02				
	12	73	0.40	2	0.10				
	1	74	0.79	5	0.13				
	2	74	0.48	2	0.12	16	0.20		
	3	74	0.82	2	0.59	16	2.38		
	4	74	0.48	7	0.51				
3930A2	5	73	0.28	5	0.10				
	6	73	0.31	2	0.08				
	7	73	0.14	2	0.10				
	8	73	0.04	6	0.02				
	9	73	0.02	16	0.01				
	10	73	0.07	7	0.02				
	11	73	0.11	11	0.01				
	12	73	0.16	2	0.04				
	1	74	0.31	5	0.05				
	2	74	0.20	2	0.05	16	0.08		
	3	74	0.34	2	0.24	16	0.99		
	4	74	0.20	7	0.21				

TRIBUTARY FLOW INFORMATION FOR OHIO 1/27/75

LAKE CODE 3930 HOLIDAY LAKE

MEAN MONTHLY FLOWS AND DAILY FLOWS(CMS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
393081	5	73	0.08	5	0.03				
	6	73	0.09	2	0.03				
	7	73	0.04	2	0.03				
	8	73	0.01	6	0.01				
	9	73	0.01	16	0.04				
	10	73	0.02	7	0.01				
	11	73	0.03	11	0.00				
	12	73	0.05	2	0.01				
	1	74	0.10	5	0.02				
	2	74	0.06	2	0.01	16	0.03		
	3	74	0.11	2	0.08	16	0.31		
	4	74	0.06	7	0.07				
393061	5	73	0.14	5	0.05				
	6	73	0.15	2	0.04				
	7	73	0.07	2	0.05				
	8	73	0.02	6	0.01				
	9	73	0.01	16	0.0				
	10	73	0.03	7	0.01				
	11	73	0.05	11	0.01				
	12	73	0.08	2	0.02				
	1	74	0.16	5	0.03				
	2	74	0.10	2	0.03	16	0.04		
	3	74	0.17	2	0.12	16	0.51		
	4	74	0.10	7	0.10				
393022	5	73	0.18						
	6	73	0.19						
	7	73	0.08						
	8	73	0.02						
	9	73	0.01						
	10	73	0.04						
	11	73	0.07						
	12	73	0.10						
	1	74	0.20						
	2	74	0.12						
	3	74	0.22						
	4	74	0.12						

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APPENDIX D

PHYSICAL and CHEMICAL DATA

STORET RETRIEVAL DATE 75/02/10

393001
41 06 10.0 082 43 36.0
HOLIDAY LAKE
39 OHIO

11EPALES
3

2111202
0011 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
73/07/27	13	00 0000	26.7		36	546	8.80	118	0.120	1.600	0.120	0.017
	13	00 0005	26.6	9.4		546	8.80	119	0.100	1.500	0.080	0.017
	13	00 0009	26.4	9.0		546	8.50	116	0.140	1.400	0.080	0.019
73/10/06	10	05 0000	19.7	8.2	32	506	8.40	128	0.410	2.500	0.180	0.035
	10	05 0005	19.6	7.4		508	8.00	125	0.390	2.300	0.170	0.033

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L
73/07/27	13	00 0000	0.079	43.4
	13	00 0005	0.086	
	13	00 0009	0.091	
73/10/06	10	05 0000	0.142	107.1
	10	05 0005	0.149	

STORET RETRIEVAL DATE 75/02/10

393002
41 05 31.0 082 43 50.0
HOLIDAY LAKE
39 OHIO

11EPALES 2111202
3 0018 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
73/07/27	13 30	0000	26.2		36	572	8.30	124	0.310	2.000	0.160	0.010
	13 30	0005	26.2	7.2		579	7.50	121	0.300	1.700	0.160	0.022
	13 30	0010	24.5	1.3		572	7.50	141	1.000	2.100	0.100	0.040
	13 30	0016	21.7	0.0		560	7.20	192	3.800	5.300	0.120	0.249
73/10/06	10 20	0000	20.0			530	8.10	131	0.660	3.000	0.150	0.085
	10 20	0005	20.0	7.2		532	8.00	130	0.650	2.900	0.150	0.084
	10 20	0011	20.0	7.2		532	7.90	131	0.640	2.900	0.150	0.076

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L
73/07/27	13 30	0000	0.068	14.9
	13 30	0005	0.085	
	13 30	0010	0.109	
	13 30	0016	0.408	
73/10/06	10 20	0000	0.221	56.0
	10 20	0005	0.256	
	10 20	0011	0.214	

APPENDIX E

TRIBUTARY DATA

STORET RETRIEVAL DATE 75/02/03

3930A1
41 06 18.0 082 43 46.0
UNNAMED STREAM
39151 7.5 WILLARD
O/HOLIDAY LAKE
ST HWY 162 BRDG BELO DAM
11EPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
73/05/05	09 00		0.530	1.890	0.074	0.007	0.080
73/06/02	10 30		0.126	1.500	0.370	0.014	0.060
73/07/02	08 00		0.350	2.800	1.020	0.138	0.250
73/09/16	14 00		0.115	0.910	0.154	0.020	0.075
73/10/07	11 45		0.115	2.300	0.570	0.150	0.290
73/11/11	13 30		0.510	1.300	0.320	0.044	0.105
73/12/02	09 15		0.780	1.600	0.440	0.056	0.125
74/01/05	12 00		0.156	1.500	0.360	0.012	0.090
74/02/02	11 30		2.000	1.600	0.388	0.040	0.135
74/02/16	10 00		1.900	1.400	0.310	0.030	0.105
74/03/02	14 30		1.920	1.800	0.430	0.020	0.115
74/03/16	14 00		1.600	1.700	0.375	0.025	0.180
74/04/07	13 30		1.500	1.100	0.070	0.035	0.160
74/05/03	19 15		0.470	0.500	0.015	0.020	0.045

STORET RETRIEVAL DATE 75/02/03

3930A2
41 04 30.0 082 43 45.0
UNNAMED STREAM
39 7.5 WILLARD
I/HOLIDAY LAKE
EGYPT RD BRDG 1.5 MI N OF WILLARD
11EPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
73/05/05	09	25	0.910	1.800	0.075	0.020	0.060
73/06/02	12	00	1.020	0.960	0.029	0.032	0.090
73/07/02			1.560	1.800	0.090	0.048	0.110
73/08/06	07	30	0.700	1.470	0.072	0.013	0.045
73/09/16	14	45	0.540	2.650	0.050	0.088	0.240
73/10/07	12	20	2.900	0.900	0.064	0.063	0.195
73/11/11	14	15	1.760	0.600	0.028	0.020	0.020
73/12/02	09	35	2.400	0.800	0.136	0.040	0.097
74/01/05	12	50	2.400	1.400	0.360	0.036	0.090
74/02/02	12	45	2.600	0.900	0.140	0.045	0.120
74/02/16	12	30	1.920	1.400	0.350	0.035	0.100
74/03/02	14	00	1.800	2.200	0.090	0.040	0.220
74/03/16	15	30	2.100	1.600	0.100	0.055	0.380
74/04/07	12	30	1.500	1.350	0.065	0.037	0.190
74/05/03	18	45	0.460	0.500	0.015	0.015	0.050

STORET RETRIEVAL DATE 75/02/03

393081
41 04 30.0 082 43 28.0
UNNAMED STREAM
39 7.5 WILLARD
T/HOLIDAY LAKE
0.3 W OF EGYPT RD HWY 99 JCT
11EPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
73/05/05	09 43		0.220	9.900	6.050	0.350	0.890
73/06/02	11 00		0.720	9.900	4.500	0.126	0.950
73/07/02			0.970	12.000	8.800	0.460	1.450
73/08/06	08 00		0.820	16.800	13.600	0.152	2.630
73/09/16	15 15		0.700	9.600	7.000	0.180	0.780
73/10/07	12 15		2.040	5.600	3.400	0.480	1.500
73/11/11	14 50		0.064	12.000	4.700	0.288	0.830
73/12/02	10 15		0.960	7.300	4.400	0.136	0.780
74/01/05	13 00		1.000	9.500	4.700	0.064	0.720
74/02/02	14 20		0.830	10.000	3.670	0.060	0.690
74/02/16	11 00		1.650	1.600	0.315	0.030	0.195
74/03/02	15 30		2.200	7.400	2.500	0.235	2.200
74/03/16	15 00		1.600	1.800	0.375	0.030	0.180
74/04/07			1.510	1.200	0.080	0.040	0.155
74/05/03	18 00		0.800	0.900	0.060	0.010	0.055

STORET RETRIEVAL DATE 75/02/03

393001
41 01 35.0 082 42 10.0
UNNAMED STREAM
39 7.5 WILLARD
T/HOLIDAY LAKE
LYON RD BRDG 2 MI NE OF WILLARD
HEPALES 2111204
4 0000 FEET DEPTH

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
73/05/05	10 00		0.420	2.700	0.078	0.004	0.025
73/06/02	11 30		0.850	1.890	0.105	0.017	0.050
73/07/02			8.500	1.760	0.094	0.021	0.045
73/08/06	08 30		0.058	2.000	0.170	0.016	0.040
73/09/15	16 00		0.490	0.820	0.088	0.022	0.075
73/10/07	11 15		11.600	2.200	0.083	0.089	0.185
73/11/11	15 20		0.084	0.900	0.016	0.028	0.035
73/12/02	11 10		3.600	1.100	0.032	0.020	0.035
74/01/05	13 30		3.600	0.500	0.050	0.012	0.030
74/02/02	11 00		2.640	1.000	0.035	0.015	0.035
74/02/16	11 45		1.920	1.500	0.360	0.030	0.100
74/03/02	16 00		4.300	1.800	0.070	0.075	0.410
74/03/16	14 20		1.400	1.300	0.100	0.045	0.250
74/04/07	14 00		1.520	1.500	0.270	0.025	0.095
74/05/03	20 00		0.860	0.900	0.065	0.010	0.055